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THE BLUE CRAB FISHERY IN MISSISSIPPI[1]

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ABSTRACT Analysis of 670 trawl, seine and marsh net samples collected from July 1971 through June 1973 provided data on the distribution and abundance of blue crabs in Mississippi Sound. Highest average catches were associated with salinities between 5.0 and 15.0 ppt (parts per thousand) and temperatures between 20.0 and 25.0°C.

Young crabs congregated in dredged navigational channels and in the marshes that fringe the bays and coastline. Maximum numbers were captured over soft mud bottoms.

Peak numbers of zoeae occurred in the summer and fall. Megalopae were collected in all months. Early crab stages appeared throughout the year. Width-frequency distributions suggested rapid growth.

Crabs tagged and released in Lake Borgne, La. during the fall of 1971 moved into Mississippi Sound in the vicinity of Cat Island to overwinter. Recoveries of crabs released in the St. Louis Bay, Biloxi Bay and Pascagoula River estuarine systems indicated little movement between estuaries during the spring and summer.

Identified parasites included a new microphallid trematode.

Commercial landings of blue crabs averaged 1,712,000 pounds for the 20-year period 1953–1972. Catch per unit of effort (pounds/pot day) was low during the spring and fall, peaking in the summer. Rises in the catch per unit of effort closely followed the migration of female crabs into Mississippi Sound.

INTRODUCTION

The blue crab, *Callinectes sapidus* and its smaller congener, *Callinectes similis* are abundant in Mississippi coastal waters. Blue crab landings in Mississippi amount to over one million pounds annually, and the fishery ranks third in value of all food fisheries in the Gulf of Mexico. In addition, the blue crab supports an important recreational fishery in Mississippi. Herring and Christmas (1974) estimated that sport crabbers land about 50,000 pounds annually from Mississippi waters.

Extensive investigations on the biology of the blue crab in Chesapeake Bay have been conducted by Hay (1905), Churchill (1919) and Van Engel (1958). Prior to 1952, literature concerning the biology of this species in Gulf of Mexico waters remained scarce. However, since that time, northern Gulf studies on the blue crab include those of Daugherty (1952), Darnell (1959), Menzel (1964), More (1969), Holland et al. (1971), Jaworski (1972) and Adkins (1972b). In addition, the general works of Gunter (1950), Hedgpeth (1950), Reid (1955, 1956), Breuer (1957, 1962), Simmons (1957), Chambers and Sparks (1959), Hoese and Jones (1963) and King (1971) contributed much information on this species in coastal Gulf waters. Prior to the present study, a detailed investigation of blue crab populations in Mississippi Sound and adjacent waters had not been undertaken.

Bibliographies dealing with the blue crab life history, biology and fishery have been published by Cronin et al. (1957) and Tagatz and Hall (1971).

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AREA DESCRIPTION

Mississippi Sound is a shallow estuarine area bounded by Mobile Bay on the east and by Lake Borgne on the west, and loosely separated from the Gulf of Mexico by a chain of barrier islands. Fresh water enters the Sound from the Pearl River, St. Louis Bay, Biloxi Bay and Pascagoula River watershed systems. Low-salinity waters from Mobile Bay to the east and Lake Borgne to the west also enter the Sound. The barrier islands consist primarily of beaches and dunes, with the beaches forming both sides of the islands and small swamps and ponds located in the interior (Shepard 1960). The intertidal area is almost entirely sand which gradually grades into mud away from shore. The beaches along much of the Mississippi mainland are man-made, having been pumped from adjacent offshore water bottoms. Little vegetation is found along these beaches as they are "maintained" for public recreational use. Soft mud sediments characterize the bottom of most of the Sound, except in areas near the barrier islands. Coastal bays are shallow with soft mud sediments. A more detailed description of Mississippi Sound has been reported by Christmas (1973).

Submerged vegetation near the mainland is dominated by *Ruppia maritima.* Beds of *Diplanthera wrightii, Cymodocea manatorum* and *Thalassia testudinum* are located just north of the barrier islands (Eleuterius 1973b).

Ninety-four percent of the coastal mainland marsh is dominated by *Juncus roemerianus.* Eleuterius (1973a) provided details on the composition and zonation of Mississippi marshes.

Sampling Locations

Fixed stations representing blue crab habitats were established in the St. Louis Bay, Biloxi Bay and Pascagoula River estuaries. Sampling was concentrated in the Biloxi Bay estuary. The division of Mississippi Sound into salinity zones as defined by Christmas and Eleuterius (1973) was used in establishing sampling locations (zones were arbitrarily based on average bottom salinity and geographic location). Zones were numbered from fresh water, zone 1, through the salinity gradient to saline water, zone 5 (Figure 1). Sampling sites were located in zones 2 through 5. Station locations by gear type are shown in Figure 2.

MATERIALS AND METHODS

Field and Laboratory Procedures

Simultaneous surface and bottom plankton samples were taken from July 1970 through December 1972 with Clarke-Bumpus samplers fitted with No. 3 mesh nets, towed at a constant speed for 10 minutes. Samples were preserved in the field in a 5% solution of formalin buffered with methenamine.

Settled volume of plankton was determined for each sample. Samples with settled volumes less than 5 ml were examined entirely. When volumes exceeded 5 ml, aliquots were taken with a Folsom plankton splitter.

Standard collecting gear for juvenile and adult crabs included a 16-foot otter trawl with 3/4-inch wing mesh and 1/4-inch tail mesh and a 50-foot (1/4-inch bar mesh) bag seine. Trawls were pulled for 10 minutes. Seines were set by hand or from a skiff and were pulled at various distances from the shoreline depending upon the topography of the bottom.

A marsh net with a 1-mm mesh was used to determine the distribution of postlarval and small juvenile crabs. Routine sampling for postlarval, juvenile and adult blue crabs began in July 1971 after preliminary sampling had defined optimal habitats.

All trawl, seine and marsh net samples were iced in the field and brought to the laboratory for analysis. In the laboratory, carapace width, weight, sex, maturity stage and growth stage (hard, buster, soft, buckram) were recorded for each crab. Mature females were examined to determine ovarian state using the method described by Hard (1942). Each crab was checked for parasites and epizoans.

Temperature and salinity were measured with a Beckman salinometer (Model RS5-3) at deep-water trawl and plankton stations. At shallow-water stations a mercury thermometer and a refractometer (AO Model 10402) were used. Comparisons of results from salinometer and refractometer measurements showed no significant differences. Dissolved oxygen was measured at all stations with a portable oxygen meter (YSI Model 54).

Male and female blue crabs were tagged in November–December 1971 and May–July 1972. Crabs, obtained from commercial fishermen, were tagged and released in the area of capture. A yellow "spaghetti" tag bearing the initials GCRL, Ocean Springs and serially numbered, was strung on plastic coated leader wire and attached between the large lateral spines of the carapace. The leader wire was secured as a loop by pulling the ends through a brass ferrule and clamping. Carapace width and sex were recorded before the crabs were released.

Preceding tagging in the fall of 1971, a press release was widely published, letters announcing the program were written to other Gulf of Mexico laboratories, and posters were placed at strategic points in processing plants, on public piers, at fishing camps, etc. Processing plants were visited regularly and individual crab fishermen were contacted to enlist their cooperation. Prior to the second release of crabs, in the late spring and summer of 1972, a notice was prepared for distribution to each commercial fisherman buying a license in Mississippi. Distribution of these notices was carried out by the Mississippi Marine Conservation Commission. No reward was offered for the return of tags.

A survey of the commercial catch was begun in July 1970 in the Biloxi Bay area. Data were collected on the size and sex composition of the commercial catch and on the areas of crabbing. Data on the catch per unit of effort and the number of days of crabbing were obtained from the records of commercial processing houses. Interviews were conducted with local fishermen.

LARVAL STUDIES

Callinectes sapidus spawns in coastal Gulf and estuarine waters from early spring through fall, and perhaps in winter, while *Callinectes similis* spawns in Gulf waters in all seasons. Although there is no clear evidence that *C. similis* larvae enter the Sound, the possibility of co-occurrence of the larvae in plankton samples cannot be overlooked. Since the task of separating the two species would be difficult and time consuming (Dr. C. G. Bookhout, personal communication), zoeae and megalopae were consequently identified to *Callinectes* spp.

When *Callinectes* megalopae appeared in plankton samples in January and February of 1971, samples were cultured and developed to early crab stages. All surviving crabs were identified as *C. sapidus*. Early crab stages of *C. similis* were collected in marsh net samples in the Sound. Plankton and nekton samples from offshore Mississippi waters also contained early crab stages of *C. similis* (fide Allison Perry). Early crab stages of *C. sapidus* were rarely collected in plankton samples from the Sound.

Seasonal Distribution of Larvae

Peak numbers of *Callinectes* zoeae were collected in August 1970, June, July, and September of 1971 and in June through August of 1972. Smaller numbers were collected in the spring and fall. The seasonal pattern of zoeal occurrence and abundance was coincident with the appearance of berried female blue crabs in coastal Gulf and estuarine waters. Spawning in the northern Gulf begins in early spring and continues through the fall, reaching a peak during the summer months (Darnell 1959, More 1969, Adkins 1972b). In addition to the spring, summer and fall spawning groups, Adkins noted a winter group of spawning females in the offshore waters of Louisiana. No such group has been observed in Mississippi Sound.

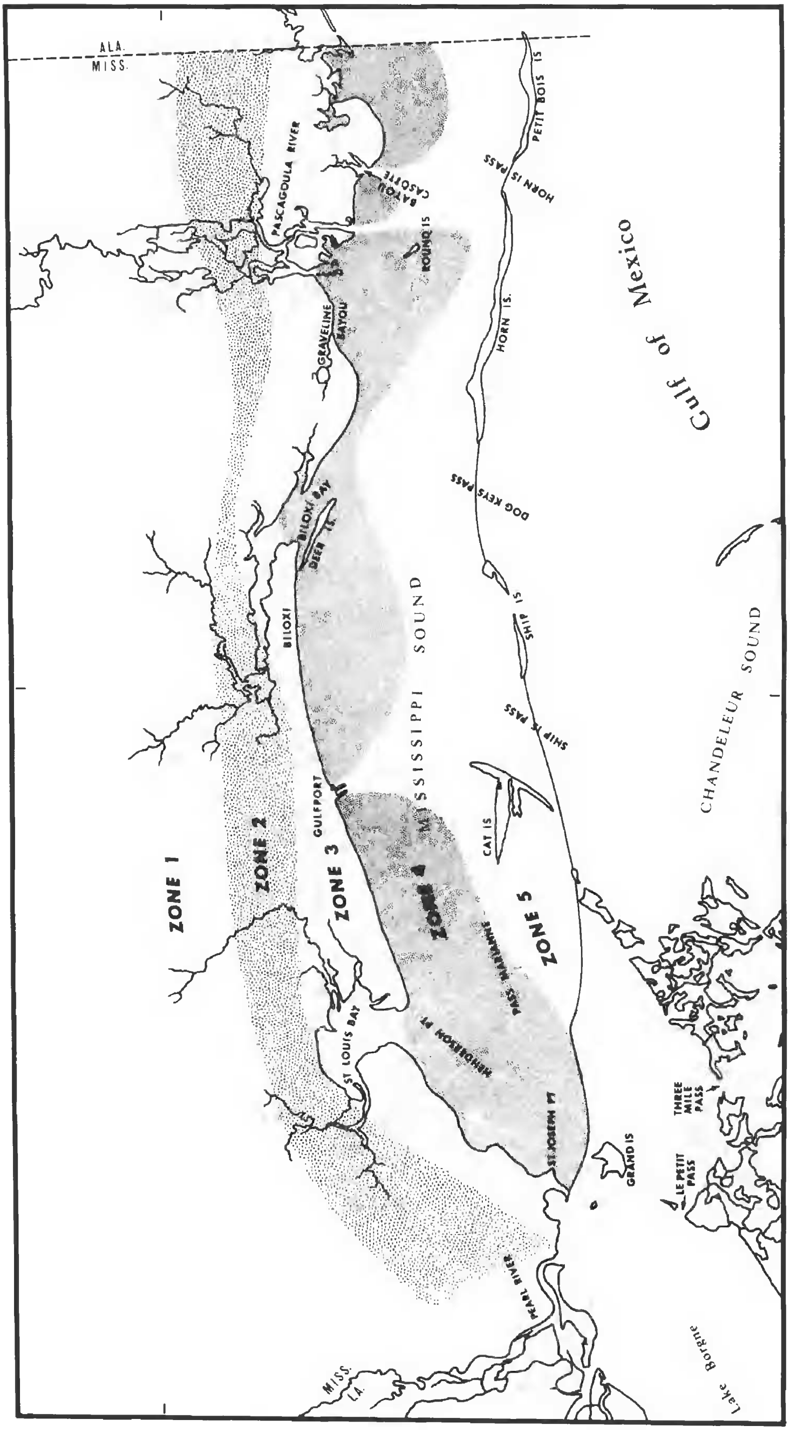

Figure 1. Salinity Zones 1–5, Mississippi Sound

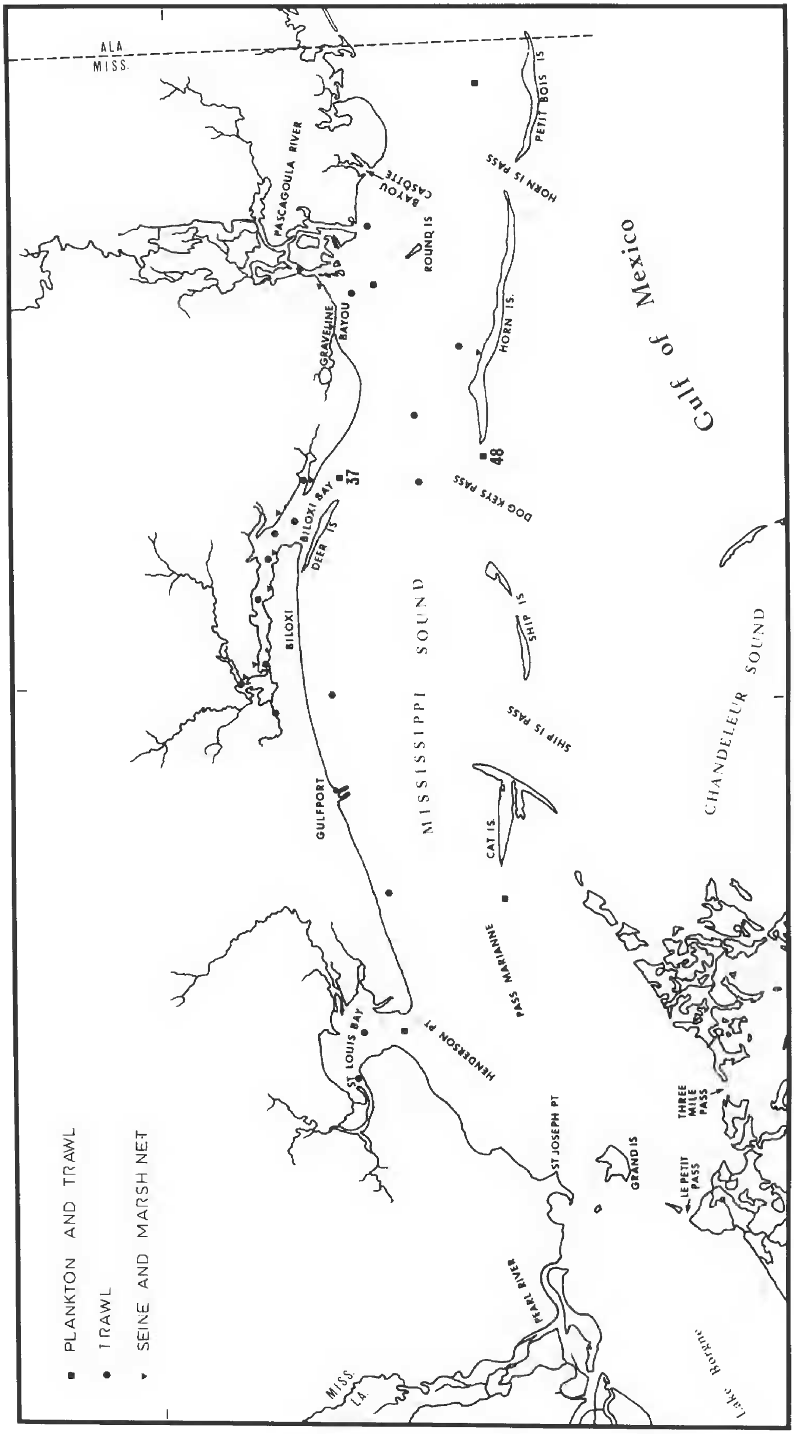

Figure 2. Location of stations.

Megalopae were collected in all seasons but were most abundant in samples collected in September 1970, February 1971 and August 1972. The origin of the winter peak of megalopae in Mississippi Sound is not known. More (1969) noted the occurrence of *Callinectes* megalopae in all months but December in Texas passes and Adkins (1972b) noted a February peak for megalopae in Louisiana. Costlow (1967) reported from laboratory studies that 50% of the megalopae held at 15.0°C in 35.0 ppt salinity survived 37–55 days before metamorphosis to early crab stages. This would allow for the overwintering of megalopae of *C. sapidus*.

Areal Distribution of Larvae

Peak numbers of zoeae were collected at station 48 in Dog Keys Pass, with numbers sharply reduced at the entrance to Biloxi Bay. Zoeae were virtually absent from the upper reaches of Biloxi Bay.

Megalopae were periodically numerous in the lower estuary, being particularly abundant in September 1970 both in Dog Keys Pass and at the entrance to Biloxi Bay and in August 1972 in Dog Keys Pass. When megalopae were abundant, they penetrated as far as the middle of Biloxi Bay. Megalopae were also collected (marsh net) along the edge of the marshes in zones 3 and 4.

Vertical Distribution

The total number of zoeae collected at the surface in Dog Keys Pass during 30 months was similar to that collected at the bottom. There was a general trend toward greater surface concentrations from July 1970 through May 1972. Beginning in June 1972 and continuing through the first sample in August 1972, zoeae were more numerous in bottom samples. It is evident that zoeae were transported via both surface and bottom currents.

Megalopae were most abundant in surface samples. Tagatz (1968a), however, found that in the area of St. Johns River, Florida, 96.0% of the *Callinectes* megalopae occurred in bottom collections.

Hydrography

Salinity, temperature and dissolved oxygen were measured when plankton samples were taken.

Temperature variations between surface and bottom samples showed maxima of 2.7°C in May 1971 and 2.5°C in March 1972 at stations 37 (10 feet) and 48 (30 feet), respectively. The highest temperature (31.3°C) was observed in August 1972 at station 37 at the surface. In general, bottom temperatures at station 48 were lower than surface temperatures with inversions occurring in July 1970, February, March and December of 1971 and in October and December of 1972. In February 1971 the bottom water was 1.3°C warmer than surface water. Bottom water was 0.2°C and 0.5°C warmer than surface water at station 37 in December 1970 and October 1971, respectively. The lowest temperature (10.5°C) was recorded in December 1972 at station 37 at the bottom.

Salinity was highly variable at the mouth of Biloxi Bay. Surface values ranged from a high of 29.1 ppt in November 1970 to a low of 2.0 ppt in May 1972. Vertical salinity gradients of 13.0 ppt were observed at this station in December 1971 and May 1972. Salinities in Dog Keys Pass were more constant, with the greatest fluctuation recorded during the winter of 1971–72. Surface salinities began to drop in December 1971 and continued through March 1972. Salinities of 13.0 ppt and 12.0 ppt were recorded in February and March, respectively. The highest salinity (34.1 ppt) was recorded at the bottom at station 48 in July 1971.

The dissolved oxygen concentration was adequate at all stations.

Discussion

Callinectes zoeae were infrequently present in sampling areas from November 1970 to April 1971 when water temperatures were below 17.0°C. Although water temperatures were somewhat warmer during the same period in 1971–1972, zoeae were still conspicuously absent from plankton samples. Areal distribution of zoeae was apparently limited by salinity. Although a few zoeae were collected in salinities below 20.0 ppt, survival over an extended period of time was not likely. Costlow and Bookhout (1959) indicated that zoeae rarely complete the first molt in salinities below 20.1 ppt. In general, *Callinectes* zoeae occurred under conditions favorable for larval growth as revealed by laboratory studies.

Callinectes megalopae were found at greater temperature and salinity extremes than zoeae. Some specimens were collected in salinities as low as 4.0 ppt, although most were found in salinities above 20.0 ppt. Megalopae were collected in February 1971 when the water temperature was 11.4°C.

Seasonal and areal distributions of zoeae and megalopae in the St. Louis Bay and Pascagoula River estuaries were in agreement with data collected for the Biloxi Bay estuary.

JUVENILE AND ADULT STUDIES

Hydrography

Figures 3 and 4 illustrate differences in surface and bottom temperatures and salinities at trawl stations in zones 2 through 5 from August 1971 through June 1973.

Temperature

Bottom temperatures at trawl stations averaged lower than surface values with few exceptions. The greatest average temperature difference between surface and bottom waters (2.4°C) was recorded in February 1973 in zone 2. Temperature maxima and minima occurred in zone 2 in August 1971 (33.0°C) and in zones 3, 4 and 5 in January 1973 (10.0°C), respectively. Temperature ranges in the following discussions refer to averages.

Surface temperatures in zone 2 varied from a low of 12.2°C in February 1972 to a high of 33.0°C in August 1971. Bottom temperatures averaged somewhat lower,

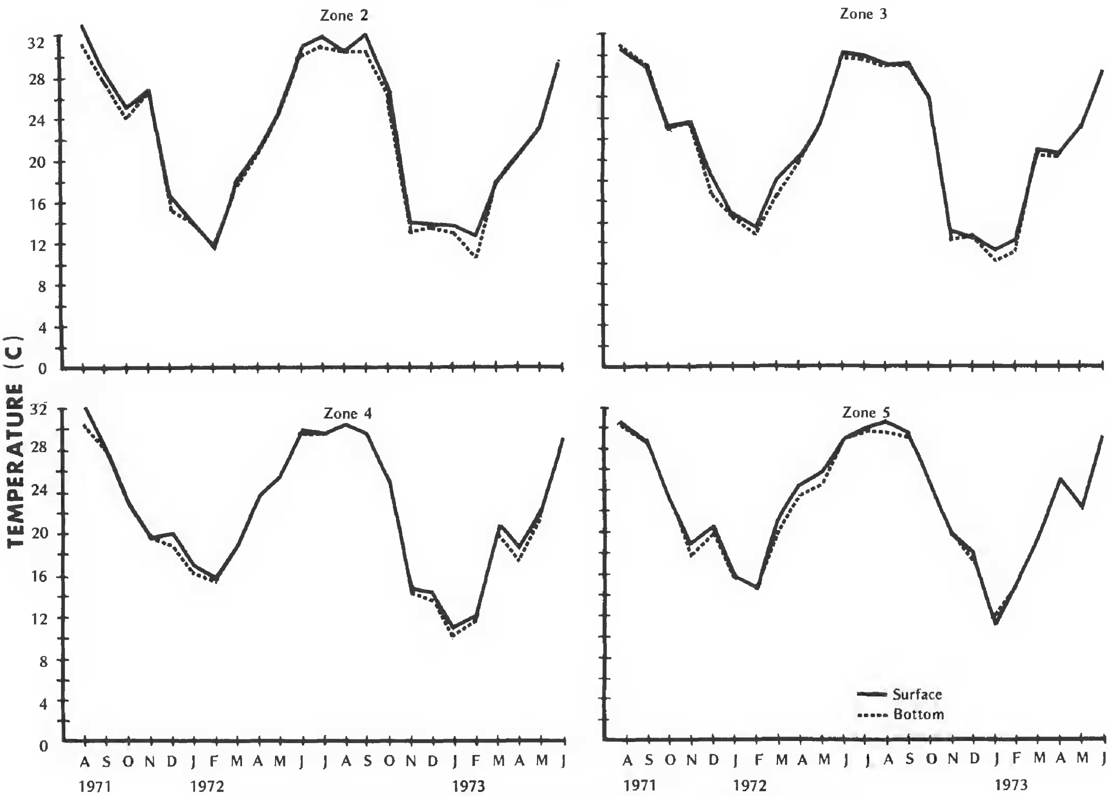

Figure 3. Average monthly surface and bottom temperatures, zones 2 through 5

ranging from 10.4°C (February 1973) to 31.1°C (August 1971).

Temperatures in zone 3 ranged from 11.1°C (January 1973) to 30.2°C (June 1972) at the surface and from 10.2°C (January 1973) to 30.5°C (August 1971) at the bottom.

Zone 4 surface readings varied from a low of 10.8°C recorded in January 1973 to a high of 32.0°C recorded in August 1971. Bottom readings ranged from a low of 10.0°C in January 1973 to a high of 30.6°C in August 1971.

Surface temperature extremes in zone 5 ranged from 10.8°C (January 1973) to 30.6°C (August 1972). Bottom temperatures averaged lowest in January 1973 (11.8°C) and highest in August 1971 (29.9°C).

Water temperatures followed a seasonal pattern with maxima in the summer months (June, July, August) and minima in January or February.

Temperatures in zones 2, 3 and 4 began to decline in December of 1971 and in November of 1972. Averages for November 1972 in these zones were considerably lower than averages in November of 1971. No significant difference in November temperatures was observed in zone 5.

Areal variations in temperature were slight. In general, the seasonal and areal temperature variations observed in the present study were in close agreement with existing data as reported by Christmas, Gunter and Musgrave (1966) and Christmas and Eleuterius (1973).

Salinity

Bottom salinities at trawl stations always averaged higher or equaled surface values. Salinities were lowest in zones 2 and 3 and increased through zones 4 and 5.

Salinities at the surface in zone 2 averaged below 5.0 ppt in 16 of the 23 months. The highest reading (16.0 ppt) was recorded in October 1972. Vertical salinity gradients in this zone ranged from 0.0 ppt (September 1971, January–March 1972, May 1972, March–April 1973) to 10.3 ppt (December 1972). Bottom salinities averaged slightly higher, ranging from 0.0 ppt (September 1971, January–March 1972, May 1972, March 1973) to 17.0 ppt (October 1972). Salinities in zone 2 were fresh when river discharge was high. The presence of a salt-water wedge was periodically detected in this zone and was particularly evident in December 1972 when surface salinities averaged 3.7 ppt and bottom salinities averaged 14.0 ppt.

Salinities in zone 3 varied from 0.0 ppt (January 1972) to 21.0 ppt (September 1972) at the surface. Bottom

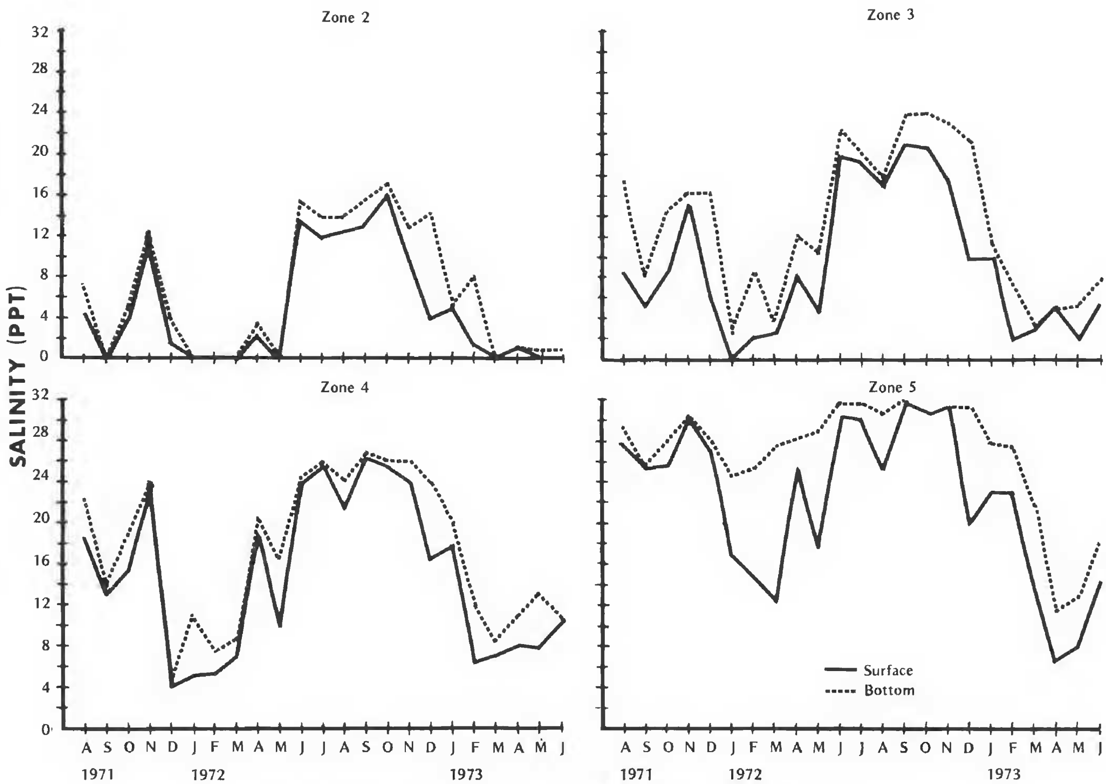

Figure 4. Average monthly surface and bottom salinities, zones 2 through 5.

salinities ranged from a low of 2.3 ppt in January 1972 to a high of 24.0 ppt in October 1972. Vertical gradients ranged from 0.0 ppt (April 1973) to 11.3 ppt (December 1972).

Zone 4 salinities fluctuated from a low of 4.0 ppt in December 1971 to a high of 26.3 ppt in September 1972. Bottom salinities ranged from 4.7 ppt in December 1971 to 26.7 ppt in September 1972. Vertical gradients ranged from 0.4 ppt (September 1972, June 1973) to 7.7 ppt (December 1972).

The lowest average surface (6.7 ppt) and bottom (11.3 ppt) salinities in zone 5 were observed in April 1973. Highest average surface and bottom salinities were recorded in September 1972, 31.7 ppt and 32.0 ppt, respectively. Vertical gradients ranged from 0.0 ppt (October–November 1972) to 15.0 ppt (March 1972).

Seasonal and areal distributions of salinity were similar to the patterns of isohalines reported for Mississippi Sound by Christmas and Eleuterius (1973).

Dissolved Oxygen

Dissolved oxygen on the surface always averaged higher or equaled bottom readings. Lowest readings were taken during late summer, followed by a steady increase in dissolved oxygen concentrations through the winter. Bottom readings averaged from a low of 3.5 ppm recorded in zone 2 in September 1972 to a high of 9.6 ppm recorded in January 1973 in zone 3. Surface averages were not observed to fall below 5.0 ppm, ranging from 5.6 ppm in zone 3 in August 1971 to 10.4 ppm in zone 3 in May 1973.

Occasionally, low individual readings were observed in all zones. Low values were usually associated with oxygen depletion in the bottom water of deep holes, or in association with swarms of the ctenophore *Mnemiopsis mccradyi.* These organisms were often collected in large numbers at both trawl and plankton stations during summer months. Christmas and Eleuterius (1973) noted that occasional temporary oxygen depletion in bottom waters is a natural phenomenon in Mississippi Sound in areas not associated with excessive BOD (biological oxygen demand) from domestic and industrial effluents.

Catch Per Unit of Effort

A total of 670 (trawl, seine, marsh net) samples collected 5,340 blue crabs from July 1971 through June 1973. An overall catch per unit of effort (all zones and all gear types combined) of 8.0 was noted for the 2-year period.

The 16-foot trawl and the 50-foot bag seine were most effective in the collection of juveniles and sub-adults.

Seine

The overall mean catch per seine haul was 8.4 during the first 12 months and 4.1 in the second period, giving an average 6.7 crabs per haul for the 24 months. Monthly means (all zones combined) ranged from a low of 0.8 in April 1973 to a high of 20.3 in June 1972. Means were 10.0 or above in July and December of 1971 and in January, June and August of 1972. High catches were associated with the appearance of large numbers of small crabs (below 40.0 mm carapace width) in shallow waters.

Seine hauls in zone 2 averaged 3.6 for the 2-year period. Yearly means were 2.9 (1971–1972) and 5.1 (1972–1973). Monthly means were below 5.0 crabs per haul for 20 of the 24 months. Highest average catches occurred in December 1971 (12.5), August 1972 (28.0) and October 1972 (20.0).

The yearly mean catch per seine haul in zone 3 was 11.4 during the first year, dropping to 4.6 during the second year. The overall mean catch for the 2-year period was 8.5. Monthly means ranged from 0.0 in January 1973 to 48.5 in June 1972, and were below 5.0 crabs per haul in 11 of the 24 months. Mean catch per haul was greatest in December 1971 (27.0) and June 1972 (48.5).

Crabs were absent from seine hauls in zone 4 in February and April of 1973. The highest average catch (38.5) was recorded in January 1972. Hauls averaged less than 5.0 crabs in 12 of the 24 months. The overall mean catch per haul for the 2-year period was 8.2, with yearly means of 11.7 (1971–1972) and 4.0 (1972–1973).

Seine hauls in zone 5 averaged less than 5.0 crabs in 18 of the 24 months. Yearly means of 5.4 and 2.2 were recorded for the first and second study years, respectively, with an overall 2-year mean of 4.2. Monthly means ranged from 0.0 (July 1971; June, July and September 1972; March, April and May 1973) to 19.5 (January 1972).

Trawl

The yearly mean catch per 10-minute trawl haul varied from 7.2 (1971–1972) to 16.5 (1972–1973), with an overall mean catch of 11.9 for the 2-year period.

Monthly means, all zones combined, ranged from a low of 0.9 in August 1971 to a high of 50.7 in March 1973. Monthly means were above 10 crabs per trawl in 11 of the 24 months. Maximum trawl catches during both study years occurred from late winter to spring or early summer. The monthly mean catch per haul was greatest from January through April in 1972 and from January through June of 1973.

Crabs were periodically abundant in trawls in zone 2 with the monthly mean catch per haul ranging from 1.0 (August 1971, June 1972) to 46.7 (March 1973). Yearly means were 8.8 (1971–1972) and 13.6 (1972–1973), with an overall catch per haul of 11.1 for the 2-year period.

Zone 3 produced the highest overall mean catch for the 24-month period (24.8 crabs/haul), the highest yearly means of 13.0 (1971–1972) and 30.0 (1972–1973) and the highest monthly mean of 103.0 crabs per haul in March 1973. Juvenile crabs were particularly abundant in this zone from January through June of 1973. Large aggregations of juveniles and sub-adults were collected in dredged navigational channels. A single 10-minute trawl haul in March 1973 yielded 224 individuals. Lowest monthly means occurred in August 1971 (1.3) and October 1972 (1.7). Trawl hauls were most productive in this zone in January 1972 (48.7/haul), March 1972 (36.7/haul), January 1973 (35.0/haul), February 1973 (43.7/haul), March 1973 (103.0/haul), April 1973 (44.3/haul) and June 1973 (45.7/haul).

Crabs were more abundant in trawl hauls in zone 4 in 1972–1973 than in 1971–1972, with yearly means of 22.2 and 5.5, respectively. Again in this zone, as in zone 3, there was a preponderance of small juveniles and sub-adults in maintained navigational channels. Lowest monthly means were recorded in August 1971 (1.0), September 1971 (1.3), July 1972 (1.2), September 1972 (0.3) and November 1972 (1.3). Crabs were most abundant during December 1971 (14.0/haul) and from December 1972 through June 1973 with monthly means of 19.7, 23.7, 47.0, 53.0, 58.0, 48.0 and 26.7, respectively. The average catch per haul in this zone for the 2-year study period was 13.8.

Sixteen-foot trawls pulled in zone 5 were rarely productive. Yearly means of 1.1 and 0.8 were recorded during 1971–1972 and 1972–1973, respectively. The average catch per haul was below 1.0 for 16 of the 24 months. The highest average catch of 6.3 occurred in July 1971. Means were 3.0 crabs or less for the entire study period, with the exception of July 1971. Juvenile crabs in this zone appeared to congregate in protected lagoons along the barrier islands. Seine hauls were generally more productive than trawl hauls in this zone. Although trawls pulled through the grass beds north of the barrier islands were usually void of crabs, Eleuterius (personal communication) found small blue crabs to be periodically abundant in dredge hauls in these areas.

To summarize, seine hauls indicated a continuing population of juvenile crabs in shallow water with maximum availability during the winter and summer. The overall mean catch per seine haul was highest in zones 3 (8.5) and 4 (8.2). Crabs were almost three times more abundant at seine stations in zones 3 and 4 during the first year of the study than the second year.

Crabs were periodically abundant in trawl hauls in all seasons. Highest numbers occurred from January through April 1972 and from January through June 1973. Zone 3 exhibited the highest yearly means (13.0 and 24.8) and zone 5 the lowest means (1.1 and 0.9) for both years of the study period.

The determination of a relationship between the magnitude of seine and trawl catches to the subsequent commercial catch was not attempted on the basis of two years of data.

Distribution by Temperature and Salinity

Forth-eight percent of all samples and 66% of all crabs were collected in salinities below 15.0 ppt. Highest average catches were associated with salinities between 5.0 and 15.0 ppt and temperatures between 20.0 and 25.0°C.

Separating crabs by sex (crabs under 19.9 mm were not sexed) and carapace widths in intervals of 20.0 mm revealed similar ratios of males to females in each increment (20.0 to 200.0 mm). More (1969) noted that sex ratios of juvenile crabs in Texas bays were relatively constant at each salinity level. The established differential distribution of adult male and female crabs was not evident. Two factors probably account for the lack of salinity preference observed. Since 83% of all crabs collected were below 100 mm carapace width, it is obvious that the 16-foot trawl was not efficient in the capture of adult crabs in Mississippi Sound. The salinity-temperature optima, as well as the equal male to female ratios, suggest that maximum availability of adults to trawl hauls occurred during the warmer months when mixed populations, coincident with mating, were abundant in the middle estuary.

Distribution by Habitat

Juvenile blue crabs were collected over a wide range of temperature and salinity, but were most abundant in the brackish waters of zones 3 and 4. Zone 3 had the greater catch per unit of effort. Both zones 3 and 4 contain extensive marsh areas which offer both food and protection for crabs. Crabs in these zones congregated in dredged navigational channels as well as along the marshes that fringe the bays and coastline. Channel depths in zones 3 and 4 vary from a few feet to over 30 feet and are characterized by soft mud bottoms. It is probable that these channels act as reservoirs for the collection of food and offer protection. Substrate appears to be an important factor in the distribution of juvenile crabs and their abundance over soft mud bottoms has been well documented (Tagatz 1968a, More 1969, Holland, Aldrich and Strawn 1971, Adkins 1972b). More (1969) indicated that the distribution of juvenile crabs in Texas bays may be related to bottom type as well as to salinity. Maximum numbers of young blue crabs in Mississippi Sound were associated with mud bottoms. Small crabs were consistently taken in all zones where a marsh habitat was encountered, although variations in abundance were evident. Seines pulled from open sand beaches extending to mud bottoms were also productive. Few crabs were seined off open sand beaches where adjacent sand bottoms were. Dredged channels were more productive than open water areas.

Preliminary analysis of data concerning the distribution of *C. similis* suggests that perhaps periodic overcrowding may occur in zones 4 and 5 because of overlapping habitats. *Callinectes similis* juveniles and adults were seasonally abundant in these zones.

The distribution of adult females was limited by low salinity. Field observations and regular checks of the commercial catch established their predominance in zones 4 and 5. They were collected in fewer numbers in zone 3 and were rarely captured in zone 2. Adult males were most numerous in low-salinity areas, but were occasionally observed near the barrier islands. Males and females were present in the middle estuary (zones 3 and 4) during mating seasons. The differential distribution of male and female crabs in relation to salinity has been documented by Churchill (1919), Gunter (1950), Daugherty (1952), Van Engel (1958), Darnell (1959), Tagatz (1968a), More (1969) and Adkins (1972b).

Adult males were collected throughout the year in low-salinity areas, but adult females were conspicuously absent from trawl hauls during winter months. Whether this absence was because of the relative ineffectiveness of the 16-foot trawl in the capture of adults, the migration of females to Gulf waters with decreasing water temperatures, or the effect of the intense fishing effort during the summer has not been determined.

Spawning, Maturation and Mortality of Female Crabs

Mature females collected in routine sampling as well as females obtained from the commercial catch were examined to determine ovarian development. The ovarian stages described by Hard (1942) were used to define the reproductive potential of the population.

Recently mated females (Stage I) and crabs with developing ovaries (Stage II) were observed in the spring, summer and fall. Females with mature ovaries (Stage III) occurred throughout the year. The appearance of berried females (Stage IV) in March and April indicated that overwintering Stage III females spawn when water temperatures begin to rise in the spring. Stage IV crabs were most abundant during the middle and late summer, corresponding with the influx of "Gulf" crabs from offshore waters. Stage V crabs appeared during the summer providing evidence that some females spawn twice in the study area.

Mating crabs were noted in zones 3, 4 and 5. Spawning took place in zones 4 and 5, with hatching of the eggs taking place in zone 5 (crabs with late sponges usually moved to higher salinity waters to hatch their eggs).

During August 1972, hundreds of spent female crabs littered the Gulf beach of Cat Island. These crabs were heavily infected with *Carcinonemertes carcinophila, Octolasmis lowei* and *Urosporidium crescens*. Most were heavily fouled with barnacles. Mortalities of this type have been observed in previous years along one or more of the barrier island beaches by Christmas and McIlwain (personal communication).

Growth

Early crab stages (2.5 to 9.9 mm carapace width) were collected in 19 of the 24 months under study, indicating growth to the juvenile population throughout the year (Figure 5).

Using combined seine and trawl data, growth was estimated by tracing modal progressions in monthly width-frequency distributions. Distributions were plotted by individual zone as well as by combined zones. The dominance of early crab stages made precise interpretation of width-frequency data difficult. The difficulty of obtaining reliable information concerning the growth of crustaceans using

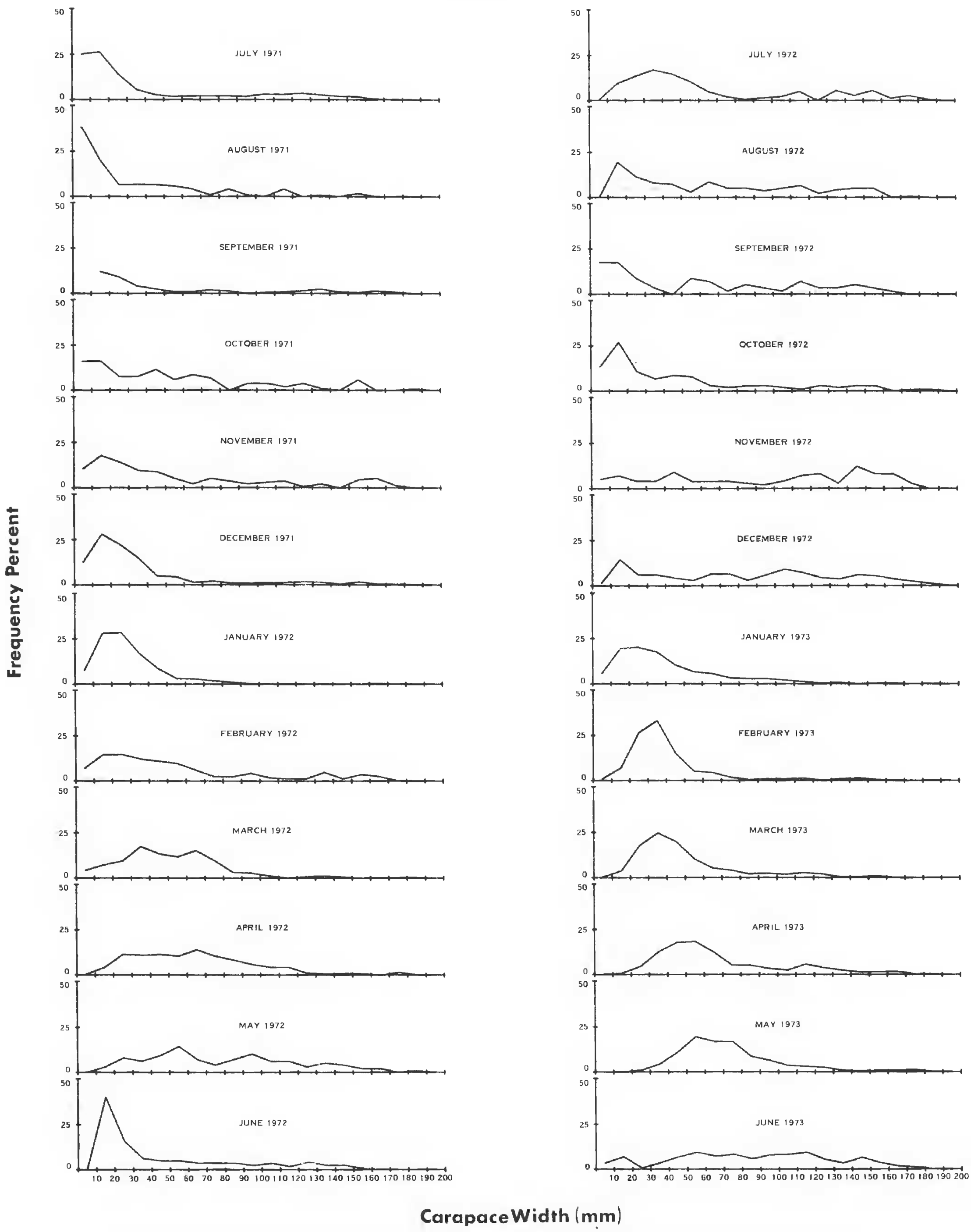

Figure 5. Width-frequency distributions of blue crabs taken from Mississippi Sound, July 1971–June 1973.

frequency distributions has been discussed by Darnell (1959).

Width-frequency distributions showed minor modes despite the continuous movement from early crab to juvenile stages. A mode established in July 1971 in zone 4 and followed through January 1972 indicated rapid growth of juveniles to adults (Figure 6). Crabs which were 15.0 mm carapace width in July were 165.0 mm carapace width in January, a gain of 150.0 mm in 6 months or an average gain of 25.0 mm per month. A second mode was observed from January 1972 through June 1973 when data from all zones were combined. Crabs which were 30.0 mm carapace width in January were 150.0 mm carapace width in June, a gain of 120.0 mm in 5 months, or an average gain of 24.0 mm per month. Growth rates (24.0–25.0 mm/month) determined for Mississippi Sound averaged higher than rates determined by More (1969) for crabs in Texas bays (15.3–18.5 mm/month) and Darnell (1959) for crabs in Lake Pontchartrain (16.7 mm/month).

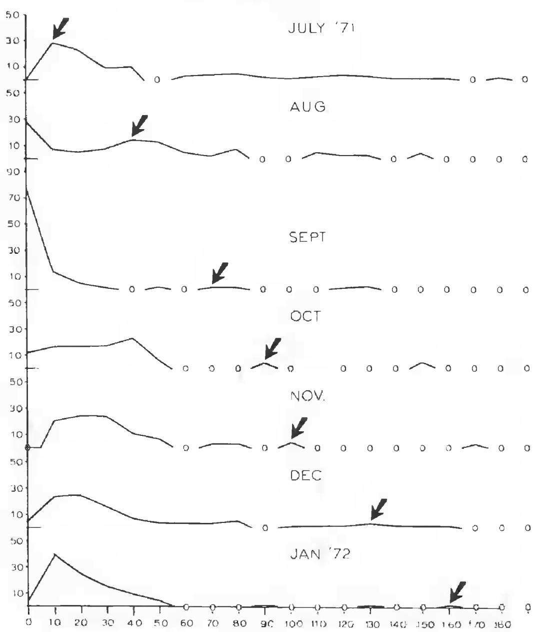

Figure 6. Width-frequency distributions of the blue crabs taken in zone 4, July 1971–January 1972.

Winter temperatures in Mississippi Sound did not appear to greatly alter the molt interval during the 2 years under study. In January 1972, 13.5% of the population sampled were in the process of shedding or had recently shed.

Data indicated that it is possible for a crab to attain commercial size in Mississippi within 10 months following hatching.

Tagging

The tagging program was divided into two phases. Phase I of the program was designed to determine the origin of the crab population moving into Mississippi Sound in the vicinity of Cat Island with the advent of cold weather. Phase II included the tagging of crabs in the St. Louis Bay, Biloxi Bay and Pascagoula River estuaries in order to determine if movement exists between estuarine systems.

Phase I–Release

According to local crab fishermen two major influxes of mature female crabs occur in Mississippi Sound. The first migration takes place in October or November and the second in the months of July and August. Repeated interviews with crab fishermen and field observations during the early part of the study established that no winter fishery for crabs existed in the areas near Petit Bois, Horn or Ship Islands. There was very limited crabbing in the Sound in the immediate vicinity of Biloxi Bay. Winter crabbing in the Sound was centered almost exclusively in the area near Cat Island where there was a sizable population of overwintering, gravid female crabs.

Adult blue crabs (155 males; 868 females) were released in three locations in Lake Borgne and in one location in Mississippi Sound (Figure 7, Table 1). All crabs tagged were obtained from a commercial source and were released near the area of capture.

TABLE 1.

Summary of release data for crabs tagged during Phase I.

Release Location	Date	Males Released	Females Released	Total
1 mile S. mouth of Pearl R.	11-22-71	19	4	23
1 mile E. of Grand Island	11-23-71	8	62	70
4 miles W. Grand Island	11-24-71	27	370	397
2 miles E. St. Joseph Point	12-8-71	101	432	533
TOTAL				1,023

Phase I–Recovery

Total recoveries through June 1975 numbered 304 (29.7% recovered), of which 44.5% were males and 27.1% were females. Ninety-eight percent of the recovered crabs were captured by commercial crab fishermen using standard wire crab pots. One percent of the crabs were recovered with other commercial gear (shrimp trawls; oyster dredges). Sport fishermen contributed to 1% of the returns. Tagatz (1968a) reported that 97% of the recoveries in St. Johns River, Florida were by commercial gear, with sport fishermen contributing only 3% of the returns. Cargo (1958) also found returns high from commercial fishermen. In direct contrast, More (1969) noted that recreational crabbers were responsible for 80% of the recoveries in Galveston Bay.

Ninety-three percent of the crabs returned during the early months of this study were recovered from seven areas (Figure 7). For this discussion these areas have been given Roman numerals I–VII. A brief description of these areas follows.

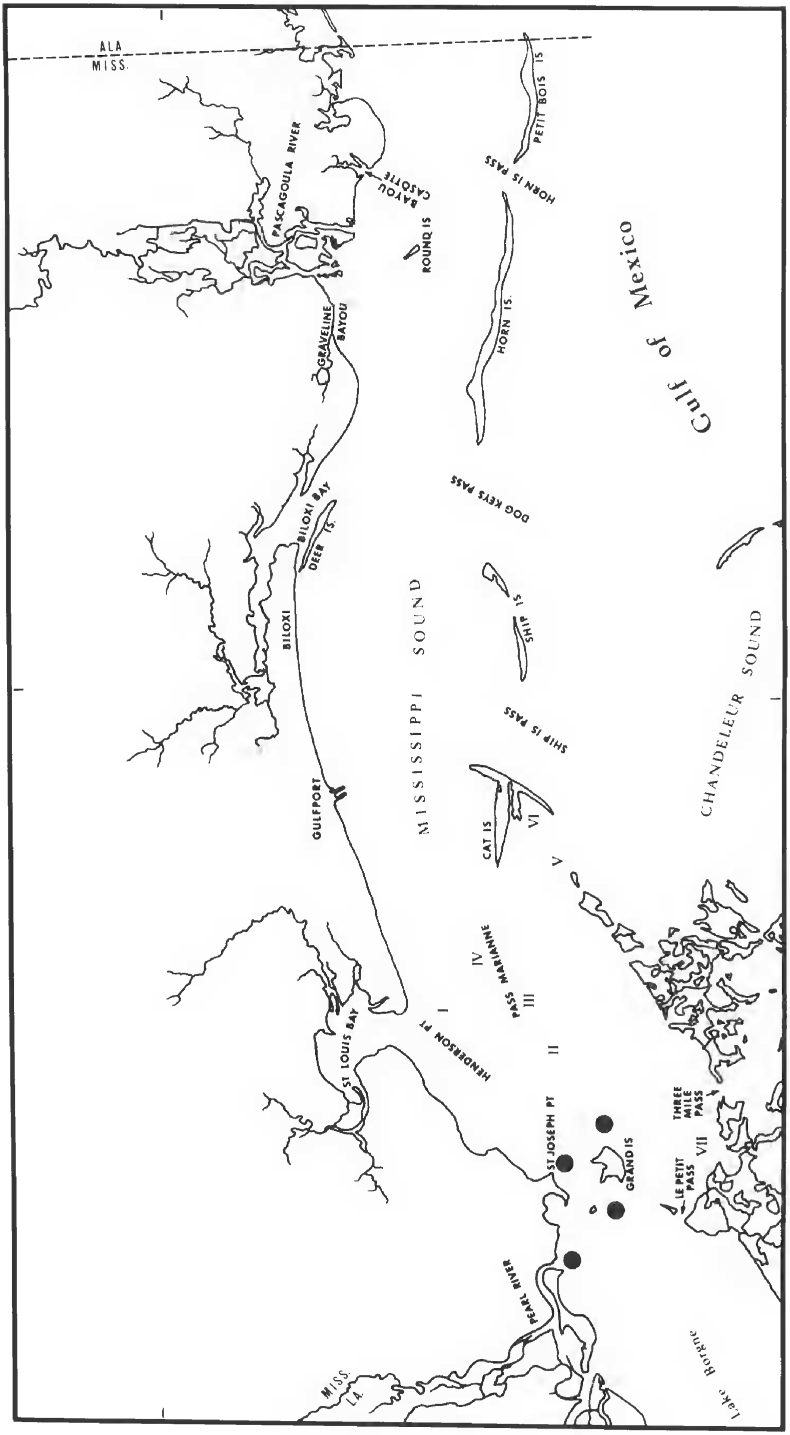

Figure 7. Location of release points and recapture areas for crabs tagged during Phase I.

Area I is located due south of Square Handkerchief Shoal in an area of active oyster production. Water depth in the area varies from 7 to 16 feet. This region was fished from November through the week of December 13, 1971 with approximately 200 commercial crab pots.

Area II is located north of Grand Island Channel in approximately 12 feet of water. This is also an area of active oyster production. Areas I and II were worked by menhaden fishermen who crabbed seasonally during the winter. Crab pots in this area numbered approximately 250.

Area III includes Telegraph Oyster Reef (Merrill Coquille) and surrounding waters. Water depth varies from 2 feet over the reef to 14 feet. Approximately 200 pots were located in the Telegraph Reef vicinity from September through December 16, 1971.

Area IV encompasses Pass Marianne Oyster Reef and the tail of Square Handkerchief Reef. Water depth varies from 4 feet over the reefs to 14 feet in Pass Marianne. This area was worked by crab fishermen from Bayou La Batre, Alabama as well as local crabbers. The number of pots in this area varied.

Area V extends along the east and west banks of Cat Island Channel and is located along an old oyster reef. Pots were moved into this area from Areas I and II the last week in December 1971. Approximately 450 pots were fished in this area through February 14, 1972.

Area VI is located south of the Middle Spit of Cat Island in the Smuggler's Cove region. Oysters are scattered in this area. Two hundred pots were moved into this area from Area III after December 16, 1971.

Area VII extends along the salt marsh from Le Petit Pass to Three Mile Pass, Louisiana. This is an area of scattered oyster production. Depths are shallow, ranging from 3 to 8 feet. Four hundred pots were fished by a single crabber in this region.

Tables 2 through 5 contain recapture data for crabs released during Phase I. The number of males (M) and females (F) recovered, distance traveled in nautical miles, time (days) from release to recapture and the direction of travel in degrees (approximate) are given.

Of the 69 males and 235 females returned, 92.3% of the females and 81.2% of the males were recovered northeast of the release sites. These crabs traveled 2 to 38 nautical miles. Time between release and recapture varied from 4 to 261 days.

TABLE 2.

Recapture data for crabs released 1 mile south of the mouth of Pearl River, November 22, 1971.

Recapture Area	M	F	Miles	Time	Degrees
III	1		13	35	74
IV	2		15	31–54	71
V	1		19	36	85
VII	4		8	36	136
Lake Pontchartrain	1		17	165	270
St. Joe Channel	1		4	197	80
TOTAL	10				

TABLE 3.

Recapture data for crabs released 1 mile east of Grand Island, November 23, 1971.

Recapture Area	M	F	Miles	Time	Degrees
I	1	2	6	19–23	35
II		2	3	11–21	46
III		2	8	25–38	53
IV		6	10	21–60	54
V		8	14	37–80	81
VI		2	16	65–93	74
VII		2	5	21–35	180
Deer Island		3	31	99–145	65
TOTAL	1	27			

TABLE 4.

Recapture data for crabs released 4 miles west of Grand Island, November 24, 1971

Recapture Area	M	F	Miles	Time	Degrees
I	1	7	11	10–28	57
II		4	9	13–23	64
III	2	5	13	16–27	67
IV		20	15	18–49	63
V	2	24	20	30–103	80
VI		14	22	36–103	75
VII	4	11	7	15–34	127
Biloxi Bridge		1	38	143	65
Deer Island		2	36	144–183	68
Pass Christian		3	17	176–181	53
Biloxi Lighthouse		1	35	201	64
Gulfport Harbor		1	26	213	57
Lake Borgne		1		49	
TOTAL	9	94			

TABLE 5.

Recapture data for crabs released 2 miles east of St. Joseph Point, December 8, 1971.

Recapture Area	M	F	Miles	Time	Degrees
I	12	18	4	4–14	53
II	5	12	2	4–15	83
III	5	11	7	8–27	77
IV	4	11	9	9–38	69
V	10	26	14	20–91	90
VI	5	26	15	29–104	84
VII	4	5	8	20	180
Bay St. Louis Bridge		2	8	261	32
Mississippi City		1	21	103	63
Pass Christian	2	1	10	167–237	52
Biloxi Lighthouse		1	28	187	66
Biloxi Back Bay	1		31	194	66
Deer Island	1		30	127	72
TOTAL	49	114			

Ten percent were recovered at points southeast to south of the release areas. These crabs were recovered in Area VII in lower Lake Borgne. Travel distance ranged from 5 to 8 miles in 15 to 16 days.

A single male crab was returned west of the point of release. This crab was tagged 1 mile south of the mouth of Pearl River and was recovered 5 1/2 months later from Lake Pontchartrain.

Discussion

From November 1971 through March 1972, commercial crabbing was concentrated in one or more of the areas in western Mississippi Sound and lower Lake Borgne (Figure 7). Nearshore crabbing was conducted on a limited basis in the Biloxi Bay area near Deer Island. Sport crabbers did not fish during this period. Early tag returns necessarily reflect the fishing pressure in these locales. Considering the bias exerted by the concentrated effort in Areas I–VII and the limited effort along the coastline, it is possible that nearshore returns would have been greater if crabbing had been homogeneously distributed throughout the Sound. Fishing effort along the coastline did not increase until the close of the oyster season in May.

The Deer Island recoveries were the first indication of movement into coastline areas with increasing water temperatures. One berried female was recovered at Deer Island 145 days after release. It is probable that the early spring spawners in Mississippi Sound are part of this population of crabs. Berried females returned from coastline areas had yellow sponges. Such crabs usually move into higher salinity waters prior to hatching of the eggs. No berried females were returned from waters south of the Intracoastal Waterway; this, again, is a function of the fishing effort along the coastline during the spring and summer.

The rate of recovery (29.7%) in the present study compares favorably with the recovery rates of Cargo (25.0%) in 1958 and Tagatz (35.0%) in 1968. The low percentage return (6.1%) reported by More (1969) was attributed to movement of the crabs away from the fishing grounds.

These results appear to confirm Darnell's theory that mated females leave the low-salinity waters (usually below 10.0 ppt) of Lakes Pontchartrain and Borgne to overwinter in Mississippi and Chandeleur sounds. A definite salinity gradient exists along a transect from the mouth of Lake Borgne eastward to Pass Marianne and Cat Island, where the average yearly salinities are 22.8 and 23.5 ppt, respectively. Ballard and Abbott (1969), working with crabs from Mississippi Sound, and Tagatz (1971) found that osmotic stress was placed upon the mature female crab in waters of low salinity and low temperature. Therefore, it would seem that migration in this particular instance might have been related to temperature and salinity. Ballard and Abbott (1969) also noted that high temperatures may favor tolerance of lower salinities by lowering the blood concentration and thus reducing osmotic work. This may, in part, explain the movement of these females into lower salinity shoreline waters as spring temperatures increase.

It is interesting that Cargo (1958) found that females in Chincoteague Bay moved in a southerly direction even if released at points where high-salinity water was to the north. He believed that the lack of a single continuous salinity gradient in the Bay might affect migratory patterns, and that the established gradient in Chesapeake and Delaware Bays might serve as an orienting factor. The movement of the Chincoteague Bay females to the south, regardless of the proximity of a salinity gradient, suggests that other factors may be influential in establishing migratory patterns in that area.

Physiographically, Mississippi's estuarine area is compound, consisting of a system of estuaries adjoining a lagoon (Emery and Stevenson 1957). The Sound is an elongate body of water partially separated from the Gulf of Mexico by a series of barrier islands. The complexity of this system does not readily lend itself to concise hydrological classification. Both north-south and east-west salinity gradients exist in addition to vertical salinity gradients. It is evident from the migratory pattern established in Phase I that travel along a salinity gradient does exist, but the forces that influence travel over a particular gradient are not known.

The migration of males parallel to females in time and distance, as observed by Tagatz (1968a), occurred in the present study as well. Tagatz noted that this migration did not occur in previous studies of crab movements.

The high rate of returns in the present study suggests that the commercial crabbers are effectively fishing this population of crabs.

Phase II–Release and Recovery

Phase II of the tagging program was carried out from May through July 1972. Crabs were released in the Biloxi Bay, St. Louis Bay and Pascagoula River estuaries.

Crabs were released in three locations in the Biloxi Bay estuary (Figure 8). Of 214 females and 78 males released, 86 females and 39 males (or 42.8%) were returned. With a single exception, all recoveries occurred within 35 days of release and 22.0% were recaptured within a week. The computation of distance traveled was not attempted. Direction of travel was random, with movements in and out of Biloxi Bay and east and west along the coastline. Males and females appeared to restrict movements within the limits of the Biloxi estuary and no migratory pattern was evident. In June 1974, 2 years after tagging, a male crab from the Biloxi release was recaptured in Pascagoula River, 8 miles upstream from the mouth. Adding these years to the time required to attain adult size, it is evident that some crabs survive for a period of 3 years in Mississippi waters.

In St. Louis Bay (Figure 8), 140 males and 112 females were released in two locations. Forty males and 13 females were returned for a recovery rate of 21.0%. All recoveries were made within 34 days of release. Movement in St. Louis Bay, as in Biloxi Bay, appeared to be random and a directed migratory pattern was not observed. Crabs moved randomly between the Bay and Sound and along the coastline. All recoveries were within the St. Louis Bay estuary.

Returns from the Pascagoula River estuary were low with only 4.8% of the crabs recovered. Crabs were released in a single location (Figure 8) and all recoveries were within 46 days of the release date. Movement between estuaries was observed when two male crabs were recovered near the St. Louis Bay Bridge and a single male was captured along the Biloxi beach front. Low returns may in part be explained by

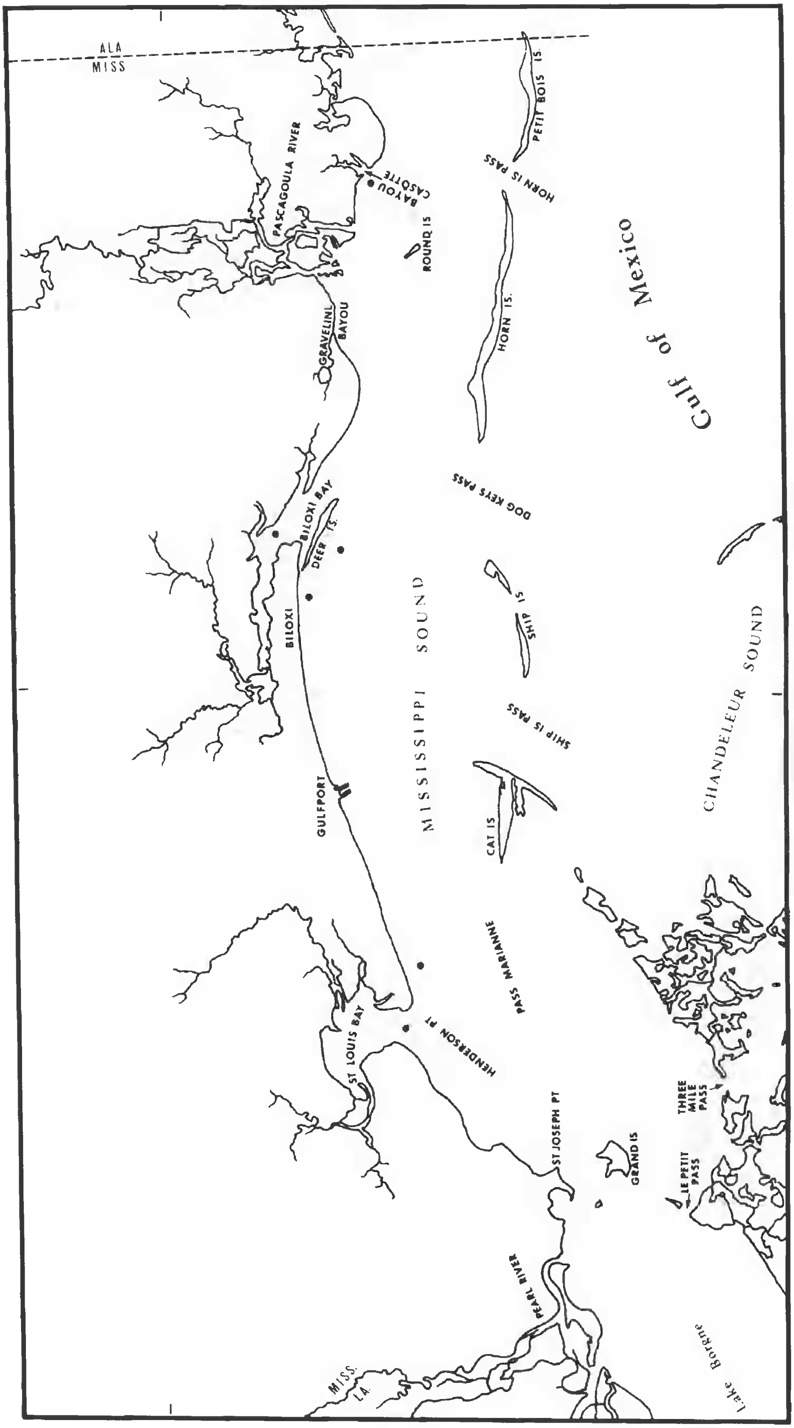

Figure 8. Location of release points for crabs tagged during phase II.

the low fishing effort in the Pascagoula system and the possibility that easterly movement made these crabs unavailable to local crab fishermen. Periodic checks of crab processors in Bayou La Batre, Alabama did not yield additional returns.

Returns from all of the estuaries necessarily reflect local fishing pressure and patterns of fishing. Fishing effort along the coastline during the spring and summer is extremely heavy from Graveline Bayou on the east to Grand Island on the west.

Parasites and Epizoans

Metacercariae of the trematode *Carneophallus basodactylophallus* were found to be infested with a haplosporidian hyperparasite tentatively identified as *Urosporidium crescens* (Overstreet 1971, personal communication). Metacercariae containing the hyperparasite were found in the hepatopancreas and musculature of the crab as well as in the gills. According to Perkins (1971), rupture of the metacercariae is necessary for the release of the spores of *U. crescens,* and this occurs after the death of the crab. He found no evidence that the trematode caused mortalities in crabs.

With the maturation of the spores of *U. crescens,* the metacercariae became blackish in color. Metacercariae containing such spores cause the condition known as "buckshot" by local crab fishermen. Crabs thus affected are also known as "pepper" crabs.

Crabs infected with *U. crescens* were taken in all seasons. Infections were present in mature and immature crabs of both sexes. Since the presence of *U. crescens* was detected only by gross observation of the mature spores, it is highly probable that light or very early infections were not noticed. No data were taken on the incidence of infection by the metacercariae alone. Detailed information concerning the life history of *C. basodactylophallus* has been published by Bridgman (1969).

The rhizocephalan parasite, *Loxothylacus texanus* was found on less than 1.0% of the crabs. Christmas (1969) noted that the rate of infection in 1966 in Mississippi Sound was negligible. Gunter (1950) observed that only 1.5% of the crabs collected in Aransas and Copano bays, Texas were parasitized. More (1969) found 8.0% and 5.8% infection rates in crabs examined from the lower Laguna Madre and upper Laguna Madre, respectively, with the incidence of infection never exceeding 1.0% in other Texas bays. The parasite appears to be a more serious problem in Louisiana waters. Ragan (personal communication) reported that infection rates in selected Louisiana estuaries may approach 50% during the warmer months. Notes on the occurrence and distribution of this parasite in Louisiana waters (Terrebonne Parish) have been published by Adkins (1972a). Reinhard (1950a, 1950b, 1951) discussed the morphology and life history of this parasite and its effect on the morphology of the blue crab.

Carcinonemertes carcinophila, a parasitic nemertean, was observed on the gills and egg masses of mature female crabs. Hopkins (1947) discussed the use of this worm as an indicator of the spawning history of *C. sapidus.*

Levinseniella (Monarrhenos) capitanea a microphallid trematode, was described from metacercariae found on the hepatopancreas and gonads of the blue crab. Crabs infected with these metacercariae were collected in the area of Raccoon Island, Louisiana in July and August of 1971 and from Cat Island, Mississippi in August 1971 and 1972 (Overstreet and Perry 1972).

Epizoic barnacles (*Octolasmis lowei*) were noted on the gills of male and female crabs collected from zones 4 and 5. Most infections were observed on mature individuals. More (1969) noted that 57.0% of the mature female crabs examined from the Gulf surf off Texas in 1967 were infected with this barnacle.

Leeches (*Myzobdella lugubris*) were found on specimens from areas of relatively low salinity. In all cases the leeches were attached to the abdomen and no penetration of the carapace was observed. Hutton and Sogandares-Bernal (1959) noted that this leech may have been responsible for mortality of the blue crab in Bulow Creek, Volusia County, Florida.

Chitinoclastic bacteria were found associated with lesions on the carapace of many crabs. These necrotic areas were visible as brown depressions on the carapace. Rosen (1967) stated that at present "we can only speculate about the causative agent of these lesions–the presence of chitinoclastic bacteria in the necrotic tissue does not *per se* implicate them as a primary causative agent of the necrosis." Cook and Lofton (1973) isolated chitinoclastic bacteria associated with shell disease in the blue crab and penaeid shrimp. Although one of the isolates (*Beneckea* type I) was present in all cases of shell disease encountered, there was no evidence of penetration of the epicuticle by the bacteria.

Branchiobdellid annelids were noted in the gill chambers of crabs taken from low-salinity waters. Blackford (1966) in her study of the ecology and morphology of branchiobdellid annelids epizoic on *C. sapidus,* noted that the branchiobdellids infecting crabs in Louisiana were probably commensal, and not parasitic. She reported that these annelids are not salinity tolerant and must drop off of the host when it leaves low-salinity areas.

Barnacles were the most common epizoans found associated with the blue crab in the study area. Other epizoans included mussels and various species of ectoprocts.

COMMERCIAL FISHERY STUDIES

Blue crab landings in Mississippi averaged 1,712,000 pounds for the 20-year period 1953–1972 (Lyles 1969). Yearly landings varied from a low of 907,000 pounds in 1962 to a high of 3,003,000 pounds in 1959. Landings were higher than the 1,712,000 pound average for 9 of the 20 years. Historical fishery statistics show peak landings for the state during 1945 (5,639,000 pounds) and 1948 (5,503,000 pounds). Landings do not necessarily reflect actual blue crab production in Mississippi since they include only those crabs that enter local processing plants. Mississippi landings do not include crabs taken in local waters and landed in neighboring states, nor do they include the catch of subsistence and sport fishermen.

Crab processing plants in Mississippi are mainly small operations. Only nine plants were in operation during the study period, and five also processed other seafoods (shrimp, oysters). In some instances, larger processors supplemented the local catch with crabs trucked from Louisiana or Alabama. The local winter catch supported a few of the plants but most either shut down crab operations or turned to "trucked" crabs landed in other states. Many of the plants operated below capacity due to the scarcity of pickers. Pickers were paid 35 to 60 cents per pound of picked meat throughout the study period.

Commercial crabbers were paid 10 to 14 cents per live-weight pound, depending upon the availability of crabs.

Most professional crabbers worked a five- to six-day week during the warmer months. Those who continued to crab during the winter averaged a three- to four-day week depending upon weather conditions. Many crabbers turned to oystering in the colder months.

Most of the catch was taken by means of a crab pot, with "trawl" crabs occasionally entering the catch.

The gulf crab, *Callinectes similis* did not enter the commercial catch. The stone crab, *Menippe mercenaria* was occasionally observed in the catch but was not processed.

Distribution and Composition of the Commercial Catch

The sex ratio of crabs landed in Mississippi was found to be dependent upon the season and the area fished. During winter, crabbing was concentrated in the vicinity of Cat Island and Pass Marianne. A few continued to crab in the Biloxi Bay area, their pots being located south of Deer Island. The winter catch for both areas was comprised almost entirely of mature female crabs. No crabbing was done along Horn and Ship islands during the winter. Weather conditions during the winter, the long distance to these islands, and the nature of the currents were the major factors involved.

During the spring, more areas within the Sound were crabbed. Spring and summer catches were mixed. Males were more abundant near sources of freshwater runoff, and females were generally more abundant in areas of intermediate and high salinities.

With the decline in abundance of crabs in the late summer and early fall, crabbers either turned to oystering or moved their pots to the winter crabbing areas.

The carapace width of crabs examined from the commercial catch ranged from 112.0 mm to 204.0 mm.

Catch Per Unit of Effort

Data used to determine the catch per unit of effort were obtained weekly from records maintained by cooperating processors and fishermen. These data included 19.7% of the total landings for the study period. Information furnished by them gave the numbers of pots fished, length of time the pots were fished, amount of the landings and location of the pots. The number of pots used by fishermen varied from 65 to 400.

Catch per unit of effort (pounds/pot day) was calculated as follows:

$$\text{CPUE (pounds/pot day)} = \frac{\text{Total pounds caught on day X}}{\text{Number of pots used on day X}}$$

The results are illustrated in Figure 9. The catch of 7.2 pounds/pot day in June 1973 was the highest recorded in the monthly averages.

Rises in the catch per unit of effort closely followed the migration periods of mature female crabs into the Sound. Peaks were associated with the fall-winter arrival of females from Lake Borgne and the summer arrival of females from the Gulf. The spring rise appeared to be associated with the maturation of crabs, both male and female, with warming temperatures. Crabs that entered the catch during the spring were, in most instances, "new-shedders." Tagging studies indicated that some females which were ready to spawn or females with sponges that appeared in the spring catch belonged to the older group of crabs that overwintered in the Sound near Cat Island and Pass Marianne.

Landings used to determine the catch per unit of effort (Figure 9) included the catches of several seasonal crabbers working small numbers of pots. These fishermen did not "follow" the crabs but usually located their pots in areas easily accessible to the processor handling their catch. They consistently had a lower catch per unit of effort than the full-time professional crabbers.

Total fishing effort varied from 63,390 pot days in August 1972 to 9,000 pot days in February 1972. Since many factors affect total fishing effort (weather, seasonal nature of the fishery), variations in total effort did not always follow variations in catch per unit of effort. In addition, crab fishermen in Mississippi are limited by processors as to the number of pounds they may land during the summer when crabs are abundant. Although fishing effort during the summer could be increased, the present technological level of the industry necessarily limits the amount of crabs that can be processed. During the summer of 1973, crabbers were not put on a limit and crabs landed in excess of the processing capabilities of local plants were shipped out of the state (reflected in increased landings and catch per unit of effort for June 1973). More (1969) observed that values of catch per unit of effort indicated changes in crab abundance, but he was unable to correlate those values with changes in catch or effort.

Almost all of the crabbers interviewed expressed concern over the appearance of extremely small mature male and female crabs. These crabs, known as "button" crabs, appeared in larger numbers in the spring and early summer. Females with carapace widths of 112.0 mm were observed with sponges. The cause for the maturation of these small crabs has not been determined.

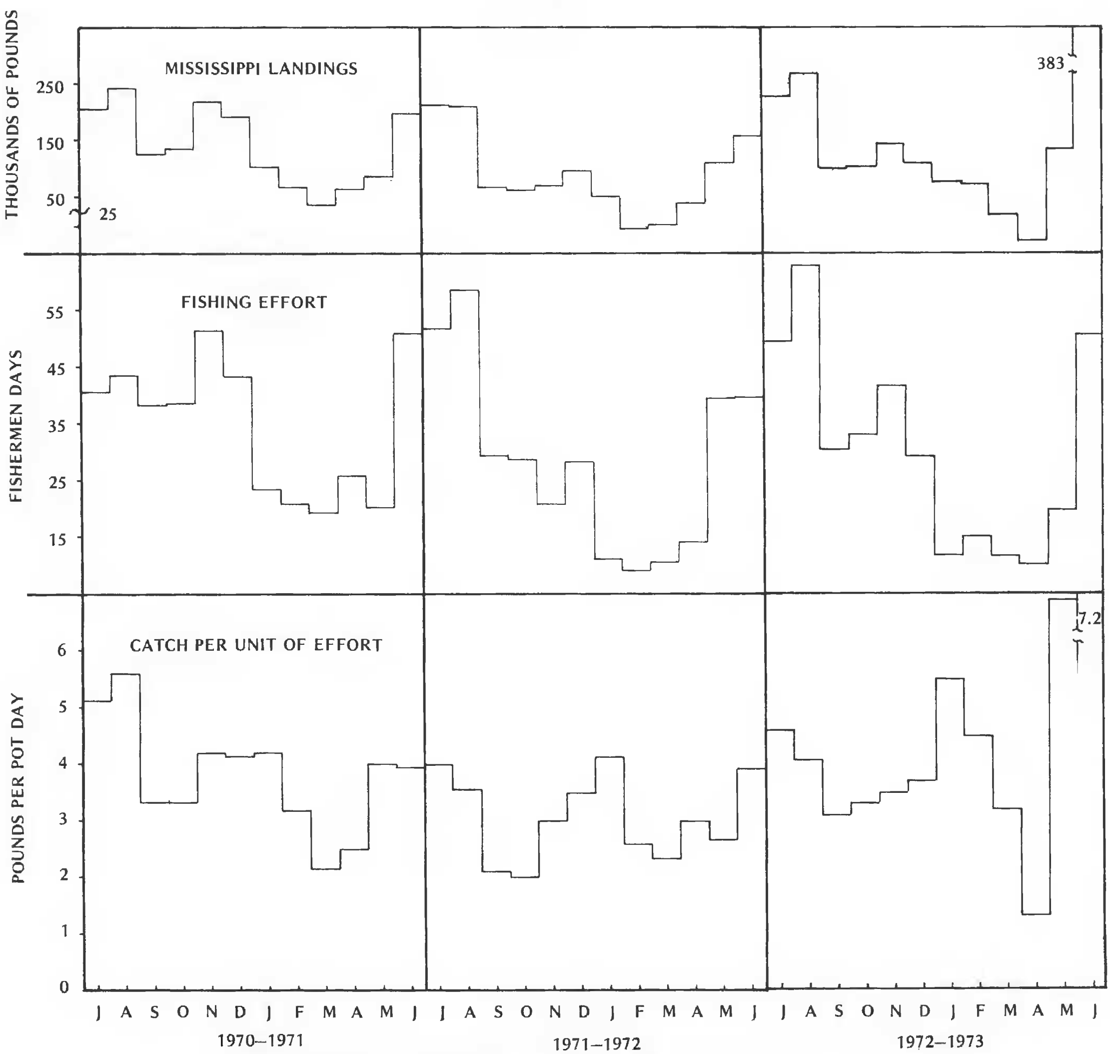

Figure 9. Monthly blue crab landings, fishing effort and CPUE in Mississippi Sound.

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